The 2007-2008 International Polar Year

Written testimony of

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I would like to begin by thanking the committee for giving me this opportunity to testify regarding the 2007-2008 International Polar Year. I was specifically asked to address the following questions from an Arctic research perspective:

- What has been learned from polar research and IPYs in the past and what do we hope to learn from this IPY?
- What are the most critical unanswered questions that you hope to resolve with the research conducted during the IPY? What are the societal benefits of this research?

Before I address those questions, let me outline for you my qualifications. In 1983, I was awarded a Bachelor's degree in Chemistry from Reed College, followed by a Ph.D. in Chemical Oceanography in 1989 from the MIT-Woods Hole Oceanographic Institution Joint Program. Following this, I undertook postdoctoral work at MIT under an NSF Women's Initiation Award and then continued my studies at the Centre National D'Etudes Spatiales, Toulouse, France, under a NATO Postdoctoral Fellowship. In 1992, I took a faculty position at the College of Oceanic & Atmospheric Science at Oregon State University, where I currently carry out research and teach as a Professor of Chemical Oceanography. Shortly after arriving at OSU, I embarked on studies in the Arctic with support of an ONR Young Investigator Fellowship. My initial objective was to devise methods to track river waters and other water types within the Arctic Ocean using naturally occurring chemical signals. Since then my research group has been applying these methods in numerous collaborative studies to document the remarkable changes in Arctic Ocean circulation over the past decade, including at the North Pole Environmental Observatory. Hence, I have been traveling to the Arctic to conduct field-based research from a variety of platforms for the past 14 years. I have served on numerous Arctic related national and international science steering and review committees. In addition, I am the mother of two children, ages 6 and 11.

In preparation for my testimony, I informed the Arctic research community via the ArcticInfo listserv of this pending hearing and requested their input via e-mail regarding the questions I was tasked to address. The timing allowed five working days for the community to respond during what is typically an active field season period for the group. Nonetheless, I received 35 responses from a broad sampling of the community. Without exception, all of the respondents endorse the importance and timing of the IPY. They brought to my attention significant issues I might have otherwise missed and so I am indebted to them for their input.

Development of the overall vision for the 2007-2008 IPY was strongly driven by community input. I personally took part in several town hall discussions early in the process that took place at various national and international science meetings. The 2004 National Research Council Report "A Vision of the International Polar Year 2007-2008" nicely captured the input and presented a path by which to proceed. I have drawn on aspects of that report for part of my testimony this morning.

In addition, I am a signatory of an open letter that was circulated in the science community beginning in 1995, proposing a program to study Arctic change. As the scientific vision developed to a broad initiative involving several federal agencies, it was galvanized under the acronym SEARCH, standing for Study of ARctic Environmental CHange. Under U.S. leadership, the international community was invited to an open science meeting in Seattle, Washington in 2003, since it was clear that SEARCH activities transcend the intellectual, infrastructural and fiscal resources of any single nation. In response to our request to foster an international effort on Arctic change, the International Arctic Science Committee and Arctic Ocean Sciences Board initiated the International Study of Arctic Change in 2004. This is the international umbrella under which SEARCH is a national component. An Interagency Program Management Committee consisting of eight U.S. federal agencies have agreed to work together on implementing SEARCH. These are the National Science Foundation (current chair), National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, U.S. Department of Defense, U.S. Department of Energy, U.S. Department of the Interior, Smithsonian Institution and the U.S. Department of Agriculture.

In May, 2005, over 80 members of the U.S. Arctic community met to align research priorities for SEARCH with the evolving thinking in the Arctic community at large. The criteria used to prioritize activities included: importance to meeting SEARCH science objectives, fit with international activities and readiness for implementation. The report that resulted is entitled "Study of Environmental Arctic Change: Plans for Implementation During the International Polar Year and Beyond" (2005, Arctic Research Consortium of the United States, Fairbanks Alaska, 104 pp.). My testimony also draws from that report and I refer you to it for further detail and original references. I would like to note that the upcoming IPY marks the first time that northern residents are being included directly in planning and implementation. The IPY vision also includes integration of social and physical sciences in the north in order to identify socioeconomic impacts of change and adaptation and mitigation strategies.

One final point I would like to make before addressing the questions is that decisions regarding the exact research programs to be sponsored during IPY have yet to finalized by several participating nations including the US. For example, science proposals submitted to the U.S. National Science Foundation are currently under review and decisions about the initial round of submissions are expected late this fall. Once the initially funded projects have been identified, it is intended that another call for proposals will ensue permitting gaps in a coherent research portfolio to be addressed. The peer review process should help to assure that the best possible ideas go forward. I am aware of attempts to coordinate funding of projects that pass our merit review system with efforts funded by other countries. This is not easy to accomplish given diverse deadlines and funding cultures but IPY will forge new ground in that direction. My answers to your questions are what the community hoped to accomplish. Based on ideas voiced during the international IPY planning process, I suspect there will be many more excellent research programs proposed than can be supported by available funds in the U.S. and our funding agencies will have some difficult decisions to make.

What has been learned from polar research and IPYs in the past?

As already pointed out, the first IPY took place in 1882-1883 and was primarily Arctic in focus. Coordinated observations were carried out at widely spaced locations. The international community demonstrated that it could collaborate in the name of science and that collective efforts can pay handsome dividends. One of the more notable findings was the first description of the large-scale motion of the sea-ice with important implications for exploration that followed. Priceless baseline data for anthropology and natural history were also obtained during this era, preserving what we now know was in the process of being lost to interactions with the lower latitude world.

The second IPY in 1932-33 heralded the beginnings of modern weather related observations around the globe and including the Arctic. Systematic Arctic Ocean observations began to be undertaken by the Russians at this time, which they continued through to the 1980's. While the Russian data collection efforts were aimed at informing their cold-war activities, that data provide us today with an essential basis for assessing the magnitude of recent changes in ice-ocean and atmosphere conditions.

Fifty years later in 1957-58, the IGY expanded its focus to include geophysical observations of the entire planet and outer space. Scientists took advantages of technology that sprung from World War II, such as rockets, satellites, radar, sonar, radio-communications, diverse telescopes and seismic sounding, to make extraordinary advances in our understanding of earth and space science. Many of the accomplishments around the globe involved a close collaboration between the military and science communities. Although polar efforts were focused more on the Antarctic, in the Arctic the first large-scale determination of the seafloor relief was accomplished. The work on the interaction of solar and cosmic particles and the earth's magnetosphere in a year of peak solar activity generated an appreciation of the cause of radio communication disruptions at the poles. The first globally synoptic weather observations were undertaken. The first submarine based surveys of sea-ice thickness were undertaken in the Arctic. Global carbon dioxide monitoring was initiated at the South Pole. The first World Data Centers were established during IGY. This is but a short list of the myriad IGY science accomplishments. The cooperative spirit of generating new knowledge overrode international tensions of the time and fostered enduring treaties regarding Antarctica and space. The public was broadly engaged by numerous media reports on the science and educational materials that evolved from it. Clearly IGY left many positive and enduring legacies.

What do we hope to learn from this IPY?

One would have to be avoiding the popular media not to realize that the Arctic has been subject to some remarkable changes over the last few decades and that many of the changes appear to be linked and are accelerating. Some of these changes are large and in certain cases, unprecedented in the period of instrumental and satellite observations. It is not an exaggeration to say that the magnitude and rapidity of recent changes caught many scientists by surprise. Quasi-cyclical atmospheric pressure patterns were initially thought to be driving many of the changes but now departures from those relationships have many of us wondering whether the Arctic is in transition to a new state altogether. What are these changes?

Arctic air temperatures are increasing. Average air temperatures have risen strongly in recent decades and are now higher than they have been in at least 4 centuries. In 2005, large portions of the Arctic were 4-7 degrees Fahrenheit warmer than they have been over the previous 26 years. Sea-ice area and thickness is diminishing. Over the period of the satellite record, summer sea-ice extent has decreased 20% (twice the area of Texas) with a record minimum in 2005, and 2006 being very close to it. Snow-covered ice reflects most incoming sunlight or as scientists like to say, has a high albedo, and water absorbs light or has a low albedo. Thus the loss of sea will change the global heat budget and so affect our global weather patterns. The ice retreat is already posing severe habitat challenges to animals dependent upon it such as the polar bear. The changing ice cover has implications for shipping routes and access to resources such as offshore oil and gas. Permafrost is warming and thawing, posing serious challenges to infrastructure, altering ecosystems and greenhouse gas emissions. Just two weeks ago, K. Walter from the University of Alaska Fairbanks and colleagues reported (Nature, Sep. 7, Vol. 443, p. 71-75) that lakes resulting from thawing in Siberian tundra probably emit 10-60 percent more of the potent greenhouse gas methane than previously estimated. Moreover their area has increased with the warming increasing their methane output from 1974 to 2000 by 58%. Woody shrubs are becoming larger and more abundant throughout the Arctic tundra as they out compete other plants, interfering with caribou migration and in some instances with oil exploration. Other plant and animal species are beginning to appear in the Arctic that have been previously unknown there. The Greenland Ice Sheet is undergoing a net melting trend that shows signs of accelerating. There are signs of concurrent ice-sheet losses in Antarctica. Recent observations highlight more dynamic response factors in ice sheet behaviors than we had previously appreciated. Realize that the Greenland Ice holds about 21 feet of potential sea-level rise; we need further observations and model improvements that incorporate these dynamic factors to anticipate the rate of future sea level changes. Freshwater cycling in the Arctic hydrologic system has been altered such that large pulses of freshwater have made their way into potentially sensitive areas of circulation in the North Atlantic that can impact our regional and global climate.

Global climate system models that take into account greenhouse gas forcing predict amplified change in the Arctic. Detailed records of climate from ice cores have taught us that change in the past has at times been very abrupt with multiple degrees of temperature change and atmospheric circulation and precipitation rearrangements occurring on less than 10 year time scales. Intensified research efforts during the IPY will come none too soon.

The IPY affords us the opportunity to accelerate the implementation SEARCH, to provide leadership and to collaborate internationally to understand and document the nature of these changes and their linkages to each other within the Arctic and to our global climate system. It appears that some amount of further change and challenges to ecosystems and human systems in the North are inevitable. We need to understand the changes to better chart their future course. What are the foreseeable benefits and difficulties of Arctic and global warming? The people of the north need answers to help them anticipate and cope with change. The effects of changes in the Arctic on global climate may well be disproportionate to its area. We need to push our understanding of Arctic-global linkages so that people outside of the Arctic can know what to expect under possible future greenhouse levels.

In addition to the very visible issue of Arctic change, there remain a number of aspects of the Arctic that are under-explored because remoteness and harsh conditions make for challenging logistics. The science community has developed new approaches and tools that are ripe for application during the IPY and so intensified research can be expected to foster new discoveries in several realms. For example, the Gakkel Ridge is the slowest spreading ridge in the world's oceans. Preliminary evidence has shown that the nature of hydrothermal activity associated with that feature spans the full range of that observed elsewhere in the world's oceans. By current thinking, this is not supposed to be the case. Further exploration offers the possibility of entirely new insights in marine geology. Another example is that the geomagnetic North Pole is currently on the rapid move. Recent studies of marine and lake sediments have revealed similar shifts of the pole's position and repeating patterns in the past that may lead to a better understanding of the behavior of the earth's core. IPY activities could help unveil tantalizing links between the earth's magnetic field position, solar and cosmic particle flux and climate.

Another example is that much of what we know about past climate on earth comes from what we call proxies or signals preserved in ice cores, sediments and organisms. There are plans to conduct scientific drilling for the first time in ocean sediments in the Bering Sea region to determine the climate and ecological impacts of the Bering Sea Bridge that emerges during low sea-level stands as well as volcanic eruptions in the region. The ice-coring community is hoping to obtain the first complete ice record from Greenland that extends back through the interglacial period at the Eem site. Advances in trace element and isotope geochemistry offer the possibility of developing and applying new proxies for teasing out the past conditions. The international community has embraced a program called GEOTRACES to track the behavior of such trace elements and isotopes in the world's oceans and has targeted their initital observations in polar regions as part of the IPY. GOETRACES also aims to provide accurate baseline information for micro-nutrients such as iron and problematic contaminants such as mercury in the polar oceans.

The integration of biological sciences during this IPY offers many new knowledge frontiers. For example, advances in molecular techniques can be applied to characterizing the diversity of organisms both north and south and potentially important functional genes such as anti-freeze proteins and UV protection of DNA. Our European and Canadian colleagues are planning to focus on migratory bird health, which has important links to avian flu and global health.

It is an exciting time to be embarking on an IPY. We have the ability to observe in seasons and places where we haven't before and at scales ranging from the molecular to the global. We are bound to make many new discoveries.

<u>What are the most critical unanswered questions that you hope to resolve with the research conducted during the IPY?</u>

The magnitude of the changes in the Arctic raises the possibility that the arctic system may be crossing a threshold or approaching a tipping point, especially if amplification or irreversibility of change is introduced through processes such as the ice-albedo-temperature feedback. Such considerations lead to the overarching question that is a main driver of the SEARCH program:

Is the arctic system moving to a new state?

Key questions that must be addressed in order to understand whether the Arctic is moving into a new state include the following:

- To what extent is the Arctic system predictable, i.e., what are the potential accuracies and/or uncertainties in predications of relevant arctic variables over different timescales?
- To what extent can recent and ongoing climate changes in the Arctic be attributed to anthropogenic forcing, rather than to natural modes of variability?
- What is the direction and relative importance of system feedbacks?
- How are the terrestrial and marine ecosystems services affected by environmental change and its interaction with human activities?
- How do cultural and socioeconomic systems interact with Arctic environmental change?
- What are the most consequential links between the Arctic and the Earth systems?

In keeping with the spirit of previous IPY's, it is also important to ask:

What new discoveries lie ahead?

<u>What are the societal benefits of this research?</u>

The Arctic is harbinger of global change and research community is poised to make unprecedented advances in understanding of our climate system at the present juncture. We will apply interdisciplinary approaches to these complex issues in a manner that wasn't conceivable during the IGY. Our observational tools have progressed dramatically. Satellites can now provide us the larger scale view of numerous essential system parameters. A wide array of in-situ sensor and autonomous platforms have been developed which can be applied to unmanned observations of the ocean, atmosphere, ice, biosphere, land, the interior of the earth and space. Modern computational as well as data storage and dissemination capabilities will allow us to move and share information in new ways. In fact, it is the hope of many of us that the IPY might provide a very visible opportunity to develop and showcase advances in cyberinfrastructure in a way the benefits the larger science enterprise.

If the IPY is fully implemented as envisioned, the Arctic as well as Antarctic plans address the future climate of our planet with the intention of establishing observation networks that take us into the future. Concentrated efforts during the IPY will help to entrain the next generation into polar science and transfer unique operational and logistics know-how to that new generation. As a mother, I am excited by the education efforts centered on the IPY that are aiming to bring fun into math and science so that we can get our kids on track and capable of competing in the global economy. The findings from IPY and the observation networks that result will help to prepare the people of the north for adapting to what appears to be inevitable change. The findings should help provide guidance for further resource development possibilities in the north under a changing climate. IPY research will provide data with which to assess environmental base line conditions and future change. The IPY data set should also advance our knowledge of past conditions on earth and improve the basis for predicting future perturbations. Finally, a firm commitment by the U.S. to the 2007-2008 IPY will demonstrate to the world that the U.S. is capable and willing to play a leading role in assuring the quality of our collective future.